

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

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**VERIDIAN ON-SITE SIDE IMPACT AIR BAG INVESTIGATION
VERIDIAN CASE NO. CA98-023
VEHICLE: 1998 CADILLAC DeVILLE
LOCATION: FLORIDA
CRASH DATE: MARCH 1998**

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. <i>Abstract</i> This on-site investigation focused on a multiple event crash that involved a 1998 Cadillac Deville. The DeVille was equipped with frontal air bags and door mounted side impact air bags for the driver and front right passenger positions. The right side impact air bag deployed as a result of an intersection-type crash with a 1992 Jeep Cherokee. The driver of the Cadillac inadvertently accelerated from the crash site and impacted a Ford Probe, entered a mobile home park and impacted numerous fixed objects with the frontal area of the vehicle. The subsequent impacts were of minor severity to the Cadillac, therefore the frontal air bags did not deploy. The 74 year old female front right passenger of the Cadillac was properly restrained by the manual belt system. She sustained multiple right rib fractures, a right pelvic fracture, and a lacerated liver from contact with the intruding right door. The passenger expired two days following the crash.			
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BACKGROUND

This on-site investigation focused on a multiple event crash that involved a 1998 Cadillac Deville. The DeVille was equipped with frontal air bags and door mounted side impact air bags for the driver and front right passenger positions. The right side impact air bag deployed as a result of an intersection-type crash with a 1992 Jeep Cherokee (**Figure 1**). The driver of the Cadillac inadvertently accelerated from the crash site and impacted a Ford Probe, entered a mobile home park and impacted numerous fixed objects with the frontal area of the vehicle. The subsequent impacts were of minor severity to the Cadillac, therefore the frontal air bags did not deploy. The 74 year old female front right passenger of the Cadillac was properly restrained by the manual belt system. She sustained multiple right rib fractures, a right pelvic fracture, and a lacerated liver from contact with the intruding right door. The passenger expired two days following the crash.



Figure 1. Overall view of the side impact damage to the Cadillac.

The crash occurred in Florida in March 1998, during daylight hours. NHTSA was initially notified of the crash by the investigating police officer on April 9, 1998, who expressed concern over the non-deployment of the frontal air bag system. The crash investigation was assigned to the Veridian Special Crash Investigation (SCI) Team on the afternoon of April 9th. The SCI COTR requested a joint investigation with a representatives of General Motors to download the sensing and diagnostic module (SDM) data. An on-site investigation was initiated on April 27.

SUMMARY

Crash Site

This crash occurred on a seven-lane divided state route at its intersection with a divided driveway for a hospital. A local street intersected the state route opposite the hospital entrance which formed a four-leg intersection. There were no traffic controls on the divided state route for north/southbound traffic flow. Traffic entering from the intersecting legs was regulated by stop signs. The 1998 Cadillac was traveling in a northerly direction on the state route, attempting a left across the southbound travel lanes into the hospital driveway.

The state route consisted of three through lanes in the northbound direction of travel with a designated left turn lane and two through lanes for the southbound travel direction with designated left and right turn lanes. Marked bicycle lanes paralleled the outboard aspect of both travel lanes with barrier curbs separating the travel lanes from concrete sidewalks. The state route was straight and level and divided by a 1.1 m (3.7') curbed median. The asphalt road surface was wet due to rain with a posted speed limit of 72 km/h (45 mph). The ambient temperature was 19 degrees C (66 degrees F) with winds of 8 knots at 290 degrees. The crash schematic is attached as **Figure 17** on Page 17.

Pre-Crash

The driver of the 1998 Cadillac DeVille was en route to an appointment at the hospital and was traveling in a northerly direction on the state route. The driver had passed through a four-leg signalized intersection that was located approximately 100 m (330') south of the hospital entrance. Standing southbound traffic for the intersection had backed up to the hospital entrance. A 1995 Ford Probe was stopped on the inboard southbound through lane at the mouth of the intersection for the hospital driveway. A 1992 Jeep Cherokee was traveling in a southerly direction on the right turn lane on an approach to the controlled intersection. The driver of the Cherokee was passing through the area of the hospital driveway en route to the intersection.

The driver of the Cadillac apparently detected the stopped Ford Probe and initiated a left turn across the southbound travel lanes into the hospital facility. It was unknown if the driver of the Cadillac failed to detect the approaching Jeep Cherokee or attempted to "beat" the vehicle across the intersection with the hospital driveway. As the Cadillac turned across the inboard right turn lane, the Jeep Cherokee impacted the right side of the Cadillac (**Figure 2**). The investigating police officer noted that there was no evidence of pre-crash braking from either vehicle on the wet asphalt road surface.



Figure 2. Left turn trajectory of the Cadillac and final rest of the Jeep Cherokee.

Crash

The full frontal area of the Jeep Cherokee impacted the right passenger compartment area of the Cadillac. Resultant directions of force were within the 2 o'clock sector for the struck Cadillac and within the 11 o'clock sector for the Jeep Cherokee. The Cadillac sustained 63.5 cm (25.0") of maximum crush that was located at the rub strip level (mid door) of the right front door, 22.2 cm (8.75") forward of the right B-pillar. The Cherokee sustained a maximum crush value of 28.6 cm (11.25") located at the right corner of the front bumper. The damage algorithm of the WinSMASH program computed velocity changes of 30.5 km/h (18.9 mph) for the Cadillac and 33.4 km/h (20.8 mph) for the Jeep Cherokee. The specific longitudinal and lateral components for the Cadillac were -15.3 km/h (-9.5 mph) and -26.4 km/h (-16.4 mph). The longitudinal component for the Jeep Cherokee was -28.9 km/h (-18.0 mph). As a result of the right side impact, the Cadillac's right side impact air bag deployed.

The impact rotated the Jeep Cherokee approximately 110 degrees in a clockwise direction as it came to rest several meters south of the point of impact. At impact, the vehicle was straddling the outboard edge line of the right turn lane, facing in a westerly direction.

Following the initial right side impact, the Cadillac was displaced to its left as the 82 year old male driver inadvertently depressed the accelerator pedal of the Cadillac and steered the vehicle in a counterclockwise direction. The vehicle completed an approximate 360 degree CCW turn in the outbound lanes of the hospital's driveway and re-entered the intersection, traveling in a northeasterly direction.

The left frontal area of the Cadillac subsequently impacted the center frontal area of the 1995 Ford Probe that was stopped on the inboard southbound through lane (**Figure 3**). The impact displaced the Probe rearward and rotated the vehicle in a counterclockwise direction. The center frontal impact sequence crushed the Probe's bumper to a maximum depth of 16.8 cm (6.6") and deployed the vehicle's frontal driver and passenger air bags. The damage to the Cadillac was minimal as the vehicle continued in a northeasterly direction. The 12 o'clock impact force to the Cadillac did not provide a sufficient longitudinal deceleration to deploy the vehicle's frontal air bag system. The SDM recorded a near deployment crash event for this impact sequence.



Figure 3. Subsequent trajectory of the Cadillac and impact with the Ford Probe.

The driver continued the inadvertent acceleration of the Cadillac as he drove the vehicle through the stopped position of the Ford Probe and rotated the vehicle in a clockwise direction. The vehicle traversed the southbound travel lanes and mounted the curbed concrete median. The Cadillac continued on a diagonal trajectory across the northbound travel lanes of the state route and departed the east road edge. Again, the Cadillac mounted a barrier curb which bordered the east edge line. There was no residual damage to the tire and/or wheel assemblies of the Cadillac and no evidence of undercarriage contact.

The Cadillac traversed a concrete sidewalk and impacted and penetrated a chain link fence that was located 26.4 cm (10.4") outboard of the referenced curb line. The full frontal area of the Cadillac was abraded by the fence impact, however, no residual crush resulted from the yielding object. The vehicle overrode several small shrubs that were located directly inboard of the fence. No significant deceleration resulted from the latter impact sequences.



Figure 4. Continued trajectory of the Cadillac and impact with the fence and utility pedestal.

The Cadillac continued across a vacant mobile home site following the fence and shrub impacts. The frontal area of the vehicle impacted and overrode a utility pedestal that contained the electric, natural gas, and plumbing lines for connection to a mobile home. The impact fractured the PVC conduits which resulted in a gas leak and a subsequent fire of the venting natural gas (**Figure 4**).

The driver of the Cadillac maintained pedal pressure against the accelerator as the vehicle continued on a straight line trajectory. The Cadillac traveled approximately 15.8 m (52.0') in a northeasterly direction and

impacted the front corner of a aluminum addition attached to a mobile home. The left front corner impact resulted in sideswipe-type damage that extended the full length of the left side of the vehicle. Damage to the aluminum addition was minor (**Figure 5**).



Figure 5. Lookback view of the impact sequence with the mobile home.

Following the mobile home impact, the driver maintained pedal pressure against the accelerator as the vehicle traversed a concrete driveway and lawn area for the mobile home. Acceleration marks from both front tires were visible on these surfaces. While traversing the lawn area, the driver applied a counterclockwise (CCW) steering input as the vehicle entered the local two-lane street for the mobile home park. The steering input resulted in a CCW arcing trajectory as the Cadillac entered and departed the left side of the local street over a longitudinal distance of 9.1 m (30').

The center area of the Cadillac's front bumper impacted and overrode a small diameter palm tree that was located approximately 3.7 m (12.0') outboard of the left side of the local street. The vehicle continued on a forward trajectory and impacted the left side of a parked 1996 Chevrolet pickup truck (**Figure 6**). The front right corner impact produced superficial abrasions to the bumper fascia of the Cadillac. The pickup truck sustained sideswipe-type damage to the left side area and was displaced in a clockwise direction on the concrete parking pad.



Figure 6. Acceleration marks across the lawn and subsequent impact with the pickup truck.



Figure 7. FRP of the Cadillac engaged against the mobile home.

The pickup truck impact redirected the Cadillac in a CCW direction as it traveled on a near perpendicular path into a large air conditioner unit positioned adjacent to a mobile home. The frontal impact sequence crushed the AC unit into the side of the mobile home as the Cadillac continued forward and impacted the sill area of the elevated mobile home. The vehicle penetrated into the side of the mobile home before coming to final rest (**Figure 7**). The total travel distance for the Cadillac from the initial point of impact with the Jeep Cherokee to final rest was approximately 152 m (500'). At rest, the engine of the Cadillac was stalled which probably resulted from the final impact sequence with the mobile home.

The driver of the Cadillac was an 82 year old male. He had a recent history of a stroke, however, there were no restrictions placed on his driving activities. The driver was properly restrained by the vehicle's manual 3-point lap and shoulder belt system. Initially, he responded to the 2 o'clock impact force and probably impacted the displaced front right passenger. He subsequently rebounded across the interior of the vehicle and contacted the left adjustable D-ring. The driver remained in an upright position behind the steering wheel of the vehicle, however, his driving actions were not spontaneous to the events. He loaded the manual belt webbing during the crash sequence which was evidenced by a diagonally oriented D-ring transfer on the shoulder belt webbing.

The front right passenger of the Cadillac was a 74 year old female. She was properly wearing the manual 3-point lap and shoulder belt webbing. At the initial impact, the right side impact air bag deployed from the rear aspect of the right front door panel. The bag probably expanded against the right upper arm of the passenger as a bloody-type abrasive (crosshatch) pattern was noted to the bag. She was subsequently impacted by the intruding right door as she responded laterally to the 2 o'clock impact force. Medical data identified a right pelvic fracture, multiple right rib fractures, and a laceration of the liver. The passenger was removed from the vehicle by rescue personnel and transported to a local hospital where she expired 2 days following the crash. Her death was attributed to the liver laceration.

VEHICLE DATA

The 1998 Cadillac DeVille, 4-door sedan, was manufactured on August 1997, and was identified by vehicle identification number (VIN) 1G6KD54Y6WU (production number deleted). The vehicle was equipped with a 4.6 liter V-8 engine (Northstar System) linked to a four-speed automatic, overdrive transmission with a column mounted selector lever. The six passenger sedan had four-wheel power disc brakes with anti-lock (ABS). As standard equipment, the Cadillac DeVille had full power accessories which included power windows, door lock, and seats. The vehicle was not equipped with the On-Star emergency cellular telephone system.

In addition to the power accessories, the Cadillac DeVille was equipped with a Supplemental Inflatable Restraint (SIR) system which consisted of redesigned frontal air bags for the driver front right passenger positions. There was no VIN identifier or side window sticker identifying the redesigned bags. The frontal air bag system did not deploy although the Cadillac sustained multiple frontal impacts. The frontal impacts were of minor severity with yielding objects.

The Cadillac DeVille was also equipped with side impact air bags for the driver and right front passenger positions. The side impact air bags were door mounted systems. The right front side impact air bag deployed as a result of the initial impact sequence with the Jeep Cherokee. This system is further discussed in the Automatic Restraint Systems section of this summary report.

VEHICLE DAMAGE
Cadillac Exterior

The Cadillac sustained severe right side damage (**Figure 8**) from its initial impact sequence with the Jeep Cherokee. Maximum crush was 63.5 cm (25.0") located at the rub strip level of the right front door, 22.2 cm (8.75") forward of the B-pillar. The direct contact damage began on the right front fender 43.2 cm (17.0") rearward of the right front axle position and extended 189.2 cm (74.5") rearward, ending on the right rear quarter panel 43.8 cm (17.25") forward of the rear axle. The combined induced and direct contact damage (Field L) began 33.0 cm (13.0") rearward of the right front axle and extended 263.5 cm (103.75") rearward to a point that was 33.0 cm (13.0") forward of the rear axle. Six equidistance crush measurements were documented along this profile at the level of the rub strip (mid door). The crush values were as follows: C1 = 0 cm, C2 = 0.75 cm (1.9"), C3 = 58.4 cm (23.0"), C4 = 63.5 cm (25.0"), C5 = 46.4 cm (18.25"), C6 = 0 cm.



Figure 8. Damage profile to the right side of the Cadillac.

The front bumper of the Jeep Cherokee overrode the sill area of the Cadillac, therefore the area of greatest penetration on the Cadillac occurred at the mid door level. The sill area of the Cadillac was involved, however, the crush depth was less severe. The sill crush at the locations of C3-C5 were as follows: C3 = 32.4 cm (12.75"), C4 = 30.5 cm (12.0"), C5 = 23.2 cm (9.1"). The Collision Deformation Classification (CDC) for this side impact was 02-RYEW-4. This impact reduced the right side wheelbase by 12.2 cm (4.8") while elongating the left wheelbase by 2.5 cm (1.0").

The right side impact severely damaged the right doors of the Cadillac. Both door units were jammed closed and the tempered side glazing was shattered. The windshield was cracked due to lateral displacement of the right A-pillar. The lamination of the windshield had separated adjacent to the right A-pillar, however, the bond adhesive remained intact against the inner layer of glazing.

The frontal area of the Cadillac sustained moderate damage as a result of numerous impacts with two additional vehicles, two mobile homes, and five yielding objects (**Figure 9**). The direct contact damage was separated for several of the impacts, however, an overall crush profile was documented at the bumper level and the upper radiator support level. The direct contact damages were noted as follows:



Figure 9. Frontal impacts to the Cadillac.

- The second impact event with the frontal area of the Ford Probe involved the left corner area of the front bumper fascia. A black vinyl transfer was noted to the fascia which began 67.3 cm (26.5") left and center and extended 9.5 cm (3.75") to the front left corner
- C Although the direct contact damage for the chain link fence impact (Impact #3) should have been evidenced across the full width of the bumper fascia and hood face, subtle abrasions were noted scattered across the hood face and bumper fascia. These abrasions resulted from impact with the chain link fence, air conditioner unit, and the mobile home. The abrasions began 43.7 cm (17.2") right of center and extended 82.6 cm (32.5") left of center onto the leading edge of the front fender.
- C The tree impact which was Event No. 8 in this crash sequence was evidenced by wood fibers embedded into the front vanity (license) plate. The contact evidence began 13.3 cm (5.25") right of center and extended 16.5 cm (6.5") to the left, ending 3.2 cm (1.25") left of the vehicle's centerline. Residual damage consisted of bending of the plate.
- C The contact evidence that resulted from the impact sequence (Event No. 9) with the parked 1996 Chevrolet pickup truck was located at the front right area of the vehicle. The damage consisted of longitudinally oriented abrasions to the fascia that resulted from engagement against the left side sill area of the pickup truck. The abrasions began 29.5 cm (11.6") right of center and extended 48.3 cm (19.0") to the right bumper corner. The impact resulted in sheetmetal damage to the corner of the hood face and the leading edge of the right front fender. Contact damage extended 27.9 cm (11.0") rearward of the leading edge of the fender and involved approximately 3.8 cm (1.5") of lateral crush.
- C The first mobile home (Event No. 7) that was struck by the Cadillac resulted in superficial sideswipe damage to the left side of the vehicle. Contact damage consisted of white paint transfers that began on the left front fender, 11.4 cm (4.5") rearward of the left front axle. The transfers continued 368.0 cm (144.9") rearward, ending at a point that was 87.0 cm (34.25") rearward of the left rear axle position. The impact did not produce residual crush, however, the rear view mirror was fractured from its mounting base.

As previously noted, damage profiles for the specific frontal impacts could not be separated, therefore the overall damage pattern was documented at both the bumper level and the upper radiator support panel. The combined damage length (Field L) for the frontal profile was measured from corner-to-corner which resulted in a length of 153.7 cm (60.5"). Equidistant crush values were measured at bumper level and were as follows: C1 = 2.2 cm (0.9"), C2 = 2.7 cm (1.1"), C3 = 5.1 cm (2.0"), C4 = 8.6 cm (3.4"), C5 = 9.8 cm (3.0"), C6 = 12.7 cm (5.0"). In addition to the residual crush at bumper level, the bumper energy absorbing devices (EAD) yielded evidence of compression and rebound. The left EAD had compressed 7.3 cm (2.875"), however, the unit rebounded 6.4 cm (2.5"). The right EAD compressed 7.3 cm (2.875") and fully returned to its original length. Both units had a maximum compression length of 11.4 cm (4.5").

Engagement against the side of the elevated mobile home (Event No. 11) resulted in residual crush at the

upper radiator support level. The profile at this level was as follows: C1 = 5.1 cm (2.0"), C2 = 11.8 cm (4.7"), C3 = 12.4 cm (4.9"), C4 = 12.4 cm (4.9"), C5 = 13.3 cm (5.25"), C6 = 12.7 cm (5.0").

Table 1 identifies the Event Number, the Object Contacted, and the respective Collision Deformation Classification (CDC) for each impact for the Cadillac in the multiple event crash sequence.

Table 1
Impact Events For The 1998 Cadillac DeVille

Event Number	Object Contacted	CDC
1	1992 Jeep Cherokee (V-2)	02-RYEW-4
2	1995 Ford Probe (V-3)	12-FLLS-1
3	Chain link fence	12-FDEW-1
4	Shrubs adjacent to fence	12-FDLU-1
5	Utility pedestal	12-FCLU-1
6	Hedge	12-FDEU-1
7	Mobile home addition	12-LDMS-1
8	Small diameter tree	12-FCEN-1
9	1996 Chevrolet pickup truck (parked off-road)	12-FREW-1
10	Air conditioner unit	12-FDEW-1
11	Mobile home	12-FDMW-1

Jeep Exterior

The 1992 Jeep Cherokee sustained moderate severity frontal damage (**Figure 10**) as a result of its impact sequence with the right side area of the Cadillac DeVille. The front bumper of the Cherokee was mounted directly to the front frame rails and a frame crossmember was positioned between the rails directly rearward of the bumper, therefore the frontal structure of the Cherokee was extremely rigid. The direct contact damage extended across the full width of the bumper and was 142.9 cm (56.25") in length. The crush profile at bumper level was as follows: C1 = 15.5 (6.1"), C2 = 10.2 cm (4.0"), C3 = 14.0 cm (5.5"), C4 = 11.7 cm (4.6"), C5 = 10.9 cm (4.3"), C6 = 28.6 cm (11.25").



Figure 10. Frontal damage to the Jeep Cherokee.

Cadillac Interior

The interior of the 1998 Cadillac sustained severe damage that was associated with initial impact with the Jeep Cherokee. Additional damage resulted from deployment of the right side impact air bag and occupant contacts (**Figure 11**). The driver was properly restrained and loaded the manual belt system in response to the 2 o'clock impact force. His loading force against the belt webbing produced a D-ring transfer on the inboard aspect of the webbing. The transfer was located 34.3-37.5 cm (13.5-14.75") above the stop button for the latchplate. He subsequently rebounded into the left B-pillar. The driver's head impacted the adjustable D-ring assembly. The plastic housing for the D-ring was stressed and the adjustment button was fractured as a result of the contact.



Figure 11. Overall interior view of the intrusion, deployed side impact air bag, and occupants contact points.

The front right passenger loaded the intruding right door armrest/pull handle with her right pelvic area. The contact deformed the padded component outward 1.2 cm (0.5") over a horizontal length of 12.7 cm (5.0"). Her right side and/or upper arm was contacted by the expanding side impact air bag. This contact sequence was evidenced by a blood-type cross-hatch patterned abrasion to the face of the bag. This abrasion pattern is further discussed in the Automatic Restraint System section of this summary report.

The predominant interior damage was associated with intrusion of the right side components. Maximum intrusion involved 44.4 cm (17.5") of lateral displacement of the trailing edge of the right front door panel. **Table 2** identifies the magnitude of the specific intruding components in both the front right and right rear occupant positions.

**Table 2
Passenger Compartment Intrusion of the 1998 Cadillac DeVille**

Occupant Position	Intruding Component	Magnitude	Direction
Front right	Rear edge of right front door panel	44.4 cm (17.5")	Lateral
Front right	Right front door armrest	41.3 cm (16.25")	Lateral
Front right	Mid right front door panel (flap-to-flap)	37.5 cm (14.75")	Lateral
Front right	Roof side rail	14.0 cm (5.5)	Lateral
Front right	Leading edge of right front door panel	10.2 cm (4.0")	Lateral
Front right	Mid aspect of sill	10.2 cm (4.0")	Lateral
Front right	Lower left A-pillar	7.6 cm (3.0")	Lateral

Occupant Position	Intruding Component	Magnitude	Direction
Right Rear (23)	Leading edge of right rear door panel (separated)	58.1 cm (22.9")	Lateral
Right Rear (23)	Mid right rear door panel	38.4 cm (15.1")	Lateral
Right Rear (23)	Right rear door armrest	48.3 cm (19.0")	Lateral

AUTOMATIC RESTRAINT SYSTEMS

The Cadillac DeVille was equipped with a redesigned frontal air bag system that consisted of a steering wheel mounted air bag for the driver's position and a top mounted air bag for the front right passenger position. It should be noted that the front right air bag deploys from a separation of the top instrument panel from the mid panel and not through a conventional cover flap. The system was monitored by a Sensing and Diagnostic Module (SDM) located under the driver's seat. Although the Cadillac was involved in numerous frontal impact events with fixed (yielding objects) and other vehicles, these impacts were not of sufficient magnitude to deploy the depowered frontal air bag system.

In addition to the frontal air bag system, this Cadillac was equipped with a side impact air bag system. The side impact air bags were available for the driver and front right passenger positions. The bags were mounted into the rear third aspect of the front door panels and were concealed behind symmetrical module cover flaps that were a padded component to the door panel (**Figure 12**).



Figure 12. Deployed right side impact air bag.

The side impact air bag system was monitored by the SDM. An additional sensor was located in the forward aspect of the respective door which detected the side impact and deployed the air bag. The off-side air bag (side opposite the impact) does not deploy.

The H-configuration side impact air bag module cover flaps were positioned between the simulated woodgrain trim panel and the full length door arm rest. The flaps were rectangular in shape with a horizontal parting seam length of 29.8 cm (11.75"). The upper flap was 8.3 cm (3.25") in height and 33.0 cm (13.0") in length at the top hinge point. The lower flap was 6.4 cm (2.5") in height and tapered to a bottom hinge width of 27.9 cm (11.0"). There was no damage or occupant contact damage to the cover flaps.

The side impact air bag membrane was concealed within the door mounted module assembly by a vinyl-like internal flap configuration. These flaps sealed the module assembly from the independent door panel cover flaps. The internal flaps opened at the designated tear points in an H-configuration. The side impact air bag was constructed of woven nylon-type fabrics similar to frontal air bags. The bag consisted of two separate fabrics sewn with an internal peripheral seam. The bag was a horizontal tear-drop shape with an overall length of 45.7 cm (18.0"). The forward aspect of the bag was approximately 10.2 cm (4.0") in height and expanded to approximately 25.4 cm (10.0") in height at the mid point of the bag. The bag was not tethered by an internal strap or directly vented into the passenger compartment.

Identification labeling on the deployed right side impact air bag was as follows:

16759017-07
CADILLAC KSP
TRAJ70151672

The lower inner air bag module cover flap was printed with the following identification number:

AP3278Q2R6CQ6T

Occupant contact evidence on the side impact air bag consisted of a blood-like, patterned (cross-hatch) transfer that was located on the rearward face of the bag. The transfer was 16.5 cm (6.5") in height and 10.2 cm (4.0") horizontally. The cross-hatch pattern was similar in color and consistency to blood stains on the bag, however, the pattern was consistent with a fabric transfer. It was unknown if the transfer resulted from bag expansion against the passenger right arm (exposed tissue) or if the arm was protected by a sleeve, therefore resulting in a fabric transfer. None of the investigating officers were able to recall the type or color of clothing worn by the passenger on the day of the crash. Medical information did not identify an arm abrasion that would have resulted from this transfer pattern.

SDM DATA

Representatives of General Motors conducted a simultaneous investigation with the Veridian SCI effort. One of the primary functions of the GM representatives was to download the data stored in the SDM to determine crash severity, stored system faults (if any), and the use of the driver's manual belt system. The SDM results forwarded to the Veridian SCI team concluded the following:

- The SDM recorded and stored a *NEAR DEPLOYMENT* crash event for the frontal impact.
- The Supplemental Inflatable Restraint (SIR) warning light was on at the time of the frontal crash event. This normal light on condition was caused by the side impact air bag deployment.
- Normal criteria were met which caused the SDM to command the deployment of the side impact air bag. (No delta V values were reported.)
- The crash occurred on ignition cycle number 1087. This is sixteen (16) cycles prior to when the SDM was read on 04/27/98.
- The driver's (front left) seat belt was latched at the time this crash occurred.

MANUAL RESTRAINT SYSTEMS

The 1998 Cadillac was equipped with 3-point lap and shoulder belt systems in the four outboard seated positions. The front seat belt systems consisted of independent lap and shoulder belt webbings affixed to a common latchplate that buckled into an inboard mounted buckle assembly. The lap belt retracted onto a sill mounted inertia activated retractor while the shoulder belt webbing retracted onto a retractor mounted into the lower B-pillar. The shoulder belt webbing was routed through a pivoting D-ring that was manually adjustable in the vertical position. Both left and right front seat D-rings were found adjusted to the lowest adjustment point.

Both occupants of the Cadillac were properly restrained by the manual belt systems. Driver belt usage was determined from a D-ring transfer (Figure 13) that was noted to the inboard aspect of the webbing. The transfer was located 34.3-37.5 cm (13.5-14.74") above the latchplate stop button that located at the center point of the webbing. Routine usage of the driver belt system was evidenced by wear marks on the latchplate that was consistent with frequent usage for the recorded kilometers on the odometer.



Figure 13. Driver’s manual belt system with D-ring transfer on shoulder belt webbing.

The right front passenger was restrained by the manual belt system. The initial side impact jammed the shoulder belt webbing between the intruding left B-pillar and door against the right front seat back. In addition, the intruding sill locked the lap belt webbing against the displaced seat cushion, thus preventing the belt system from retracting into the pillar and sill mounted retractors. Rescue personnel subsequently cut the right front passenger’s shoulder belt webbing to extricate the passenger from the vehicle. The shoulder belt webbing was cut 64.8 cm (25.5") above the latchplate, or 5.3 cm (2.1") below the latchplate stop button. The latchplate was released from the buckle, therefore the lap belt was not cut. There was no loading evidence on the right front belt system.

DRIVER DEMOGRAPHICS

1998 Cadillac DeVille

Driver: 82 year old male
 Height: 182.9 cm (72.0")
 Weight: 86.2 kg (190 lb)
 Manual Restraint
 Usage: 3-point lap and shoulder belt system
 Usage Source: Vehicle inspection, police crash report
 Eyewear: Prescription eyeglasses
 Vehicle Familiarity: Approximately 4 months
 Route Familiarity: Frequent travel
 Mode of Transport
 From Scene: Ambulance
 Medical Treatment: Admitted to a local hospital for treatment

DRIVER INJURIES

Injury	Injury Severity (AIS 90)	Injury Mechanism
Contusion over the right chest area	Minor (490402.1,1)	Shoulder belt webbing
Concussion, no loss of consciousness	Minor (161000.2,0)	Rebound contact into left B-pillar

DRIVER KINEMATICS

The driver of the Cadillac was in a presumed upright driving posture as he initiated a left turn into the hospital driveway. The power seat track was adjusted to a rear position. The adjustable head restraint was in the full down position with the seat back set to a slight recline position. The driver was properly restrained by the manual 3-point lap and shoulder belt system. Belt usage was confirmed by the initial observations of the first responding police officer to the crash scene. In addition, a diagonally oriented D-ring transfer was prominent on the inboard aspect of the shoulder belt webbing. There was no hardware damage to the belt system.

In response to the initial right side impact sequence with the Jeep Cherokee, the driver of the Cadillac moved on a trajectory that was lateral to his right and slightly forward. He loaded the manual 3-point lap and shoulder belt webbing which produced the diagonally oriented D-ring transfer to the webbing. His loading force against the shoulder belt webbing resulted in a contusion over the right chest area that was consistent with belt usage (per medical records). It was possible that as he continued to move laterally, the driver slid out of the shoulder belt webbing. He possibly loaded the left side of the right front passenger as she was displaced laterally inboard by the intruding right front door. There was no medical evidence to support the occupant-to-occupant interaction.

The driver subsequently rebounded across the interior of the vehicle. The posterior aspect of his scalp impacted the left adjustable D-ring assembly (**Figure 14**). The plastic adjustment panel was stressed from contact and the button was fractured. He sustained a concussion as a result of the contact, however, there was no loss of consciousness. The driver remained in the left front position of the vehicle with his right foot inadvertently depressed against the accelerator pedal and his hand(s) on the steering wheel assembly.



Figure 14. Driver rebound (head) contact to the right D-ring assembly.

The driver initiated a near 360 degree CW left turn maneuver across the mouth of the intersection as his foot remained on the accelerator pedal.

The Cadillac continued on a straight line trajectory in a northeasterly direction and impacted the Ford Probe prior to traversing the northbound travel lanes. The vehicle mounted the outboard curb and penetrated a chain link fence, traversed a grassy area, impacting a utility pedestal, hedge, and the corner area of a mobile home. These minor severity 12 o'clock direction of force impacts did not significantly displace the driver or produce further injury.

Following the impact with the mobile home, the vehicle traversed a concrete driveway and lawn area of the mobile home. The driver applied a counterclockwise (CCW) steering input as the vehicle approached a local street within the mobile home park. The steering input was initiated as he maintained pedal pressure against the accelerator. The Cadillac completed a near 180 degree CCW turn maneuver as it departed

the west side of the local street. The frontal area of the vehicle overrode a small diameter tree as the vehicle continued on a northwesterly trajectory.

The right frontal area sideswiped a parked Chevrolet pickup truck as the driver continued to steer CCW and accelerate. The frontal area of the Cadillac subsequently impacted a base mounted air conditioner unit and the side of a mobile home prior to coming to rest. The latter impacts were of minor severity and did not deploy the frontal air bag system or produce additional injury to the driver.

He came to rest in an upright attitude in the driver's position of the vehicle. The first responders to the vehicle noted that the driver was conscious, but in a confused state. The driver was subsequently removed from the left front door of the vehicle and transported to a local hospital where he was admitted for treatment of his injuries and observation. He was subsequently discharged two days following the crash.

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex: 74 year old female
 Height: 165.1 cm (65.0")
 Weight: 59 kg (130 lb)
 Manual Restraint
 Usage: 3-point lap and shoulder belt system
 Usage Source: Vehicle inspection
 Eyewear: Prescription eyeglasses, separated from face
 Mode of Transport
 From Scene: Ambulance to a local hospital
 Type of Medical
 Treatment: Admitted for treatment, expired 2 days following the crash

FRONT RIGHT PASSENGER INJURIES

Injury	Injury Severity (AIS 90)	Injury Mechanism
*Lacerated liver	Moderate (541820.2,1)	Intruding right front door panel
*Right rib fractures	Moderate (450220.2,1)	Intruding right front door panel
*Fractured right pelvis	Moderate (852600.2,1)	Intruding right front door panel armrest

*Police reported injuries, not confirmed by medical records. The family refused an autopsy.

FRONT RIGHT PASSENGER KINEMATICS

The front right female passenger of the Cadillac was in a normal seated position with the seat track adjusted to a mid to rear track position. She was properly restrained by the manual 3-point lap and shoulder belt system. Belt usage was determined from the post-crash inspection of the belt system (**Figure 15**). The shoulder belt aspect of the webbing was compressed between the intruding right door and the displaced seat back as it crossed the right front passenger. Rescue personnel cut the shoulder belt and lap belt webbings to extricate the passenger from the vehicle. The latchplate remained buckled into the inboard mounted buckle assembly. There was no loading evidence on the webbing, however, blood stains were prominent on the webbing.



Figure 15. Crosshatch pattern on the side impact air bag.

At the initial impact with the Jeep Cherokee, the right side impact air bag deployed from the rear third aspect of the door panel. As the bag was deploying, the door panel was displaced laterally inboard, intruding into the position of the front right passenger. The lap and shoulder belt secured the female passenger in the right front position as the intruding door panel loaded the right side of the occupant. The mid aspect of the door arm rest was scuffed and deformed in an outward direction from contact against the right pelvic area of the passenger. Her involvement with the door armrest resulted in a right pelvic fracture while the intruding door panel fractured her right ribs (numbers unspecified) and produced a lacerated liver.

The deploying side impact air bag expanded against the right arm and right side of the female passenger. A patterned crosshatch transfer (**Figure 16**) which appeared to be dried blood or a reddish fabric transfer was noted to the face of the side impact air bag. This transfer resulted from air bag expansion against the clothing or exposed tissue of the passenger. There was no confirmation of a soft tissue arm injury, however, blood transfers were noted to the right front adjustable head restraint, seat back support, manual belt webbing, and the deployed side impact air bag.



Figure 16. Overall view of the passenger's position, belt usage, and deployed side impact air bag.

The intrusion of the right front door panel against the outboard aspect of the seat back support compressed the belt webbing, therefore limiting the movement of the passenger during the subsequent impacts. She therefore, was restrained without belt spool-out during the subsequent travel and impacts of the Cadillac prior to final rest.

MEDICAL TREATMENT

The emergency medical technicians cut the lap and shoulder belt webbing of the right front passenger's manual belt system and stabilized her within the vehicle. She was removed on a back board and transported by ambulance to a trauma center that was located approximately 15 minutes from the crash site. At the hospital, her injuries were diagnosed and she was admitted for treatment. The passenger subsequently expired 2 days following the crash due to the liver injury. The family declined an autopsy.

VERIDIAN ON-SITE SIDE IMPACT AIR BAG
 INVESTIGATION
 VERIDIAN CASE NO. CA98-23

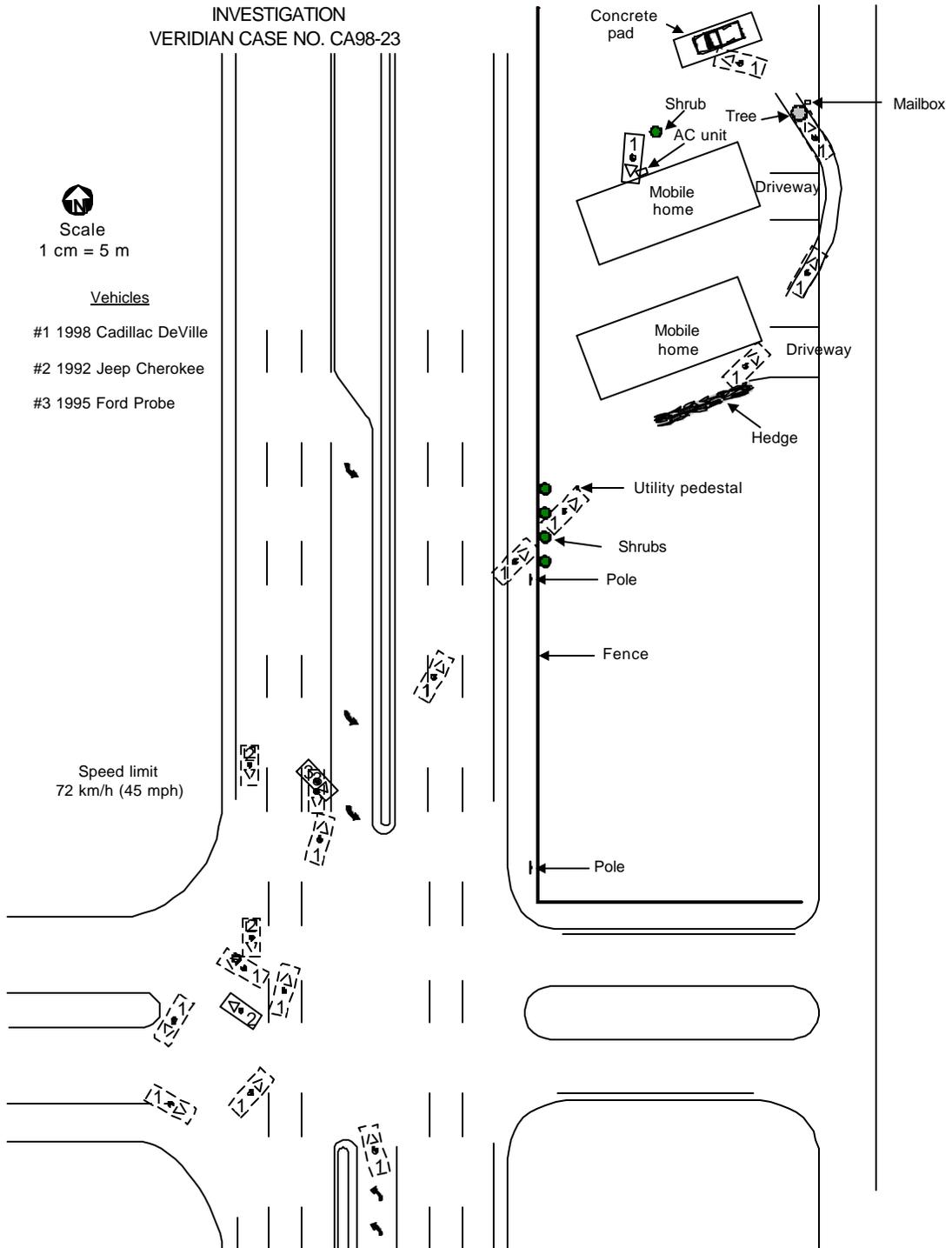


Figure 17. Crash schematic.